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INTERNATIONAL COMPUTER MUSIC CONFERENCE 1982

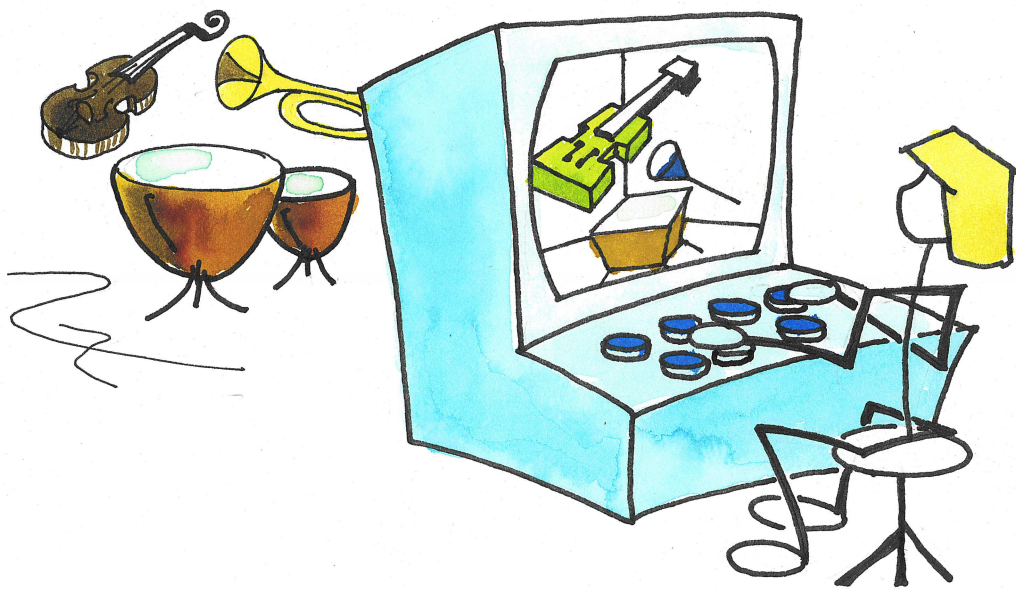
THE CONTROL CHANNELS OF INSTRUMENTAL PLAYING IN COMPUTER MUSIC  
REAL TIME IN COMPUTER MUSIC, INCIDENCE ON THE BASIC MODELS

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The first function of **COMPUTER**  
as **MUSICAL CREATION**  
**TOOL:**

The  
**REPRESENTATION**  
of **INSTRUMENTAL**  
**UNIVERSE**

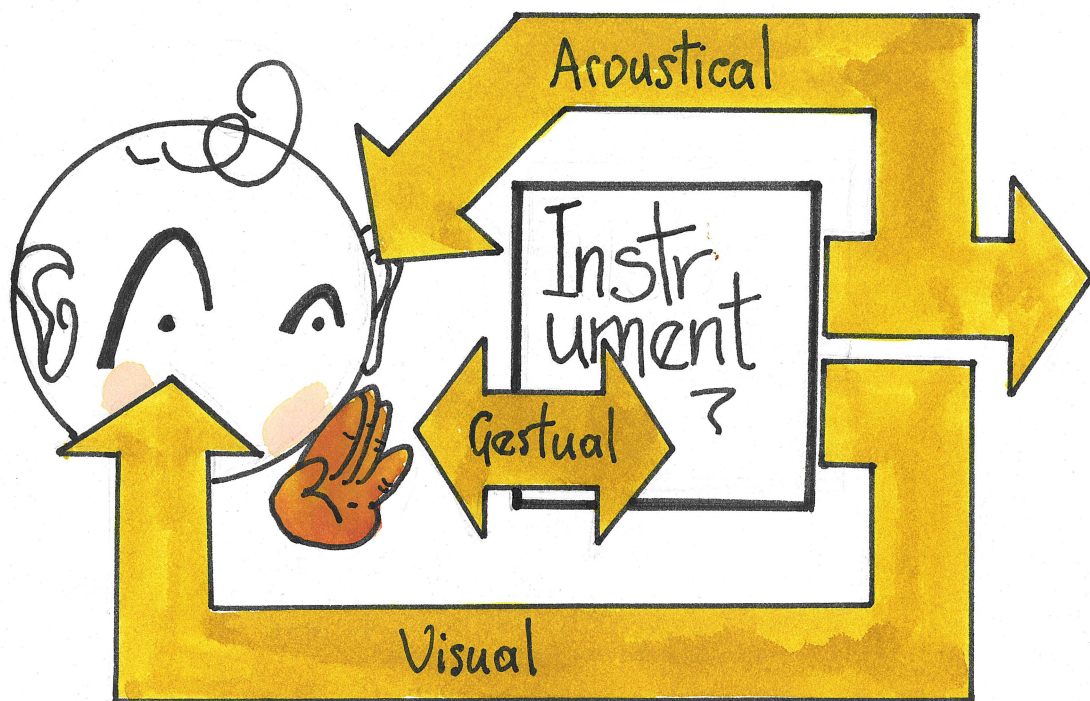


## I. THE FIRST FUNCTION OF COMPUTER AS A TOOL FOR MUSICAL CREATION

1. The purpose of our research is to build a musical creation tool turning the computer capabilities to the best account.  
We adopt an overall and complete approach to this problem and we shall present here many realisations and experiments on this subject.
2. Computer technology is a far more powerful context for experimentation than the classical technologies used up to now in musical practices.
3. Indeed, musical practice begins with instrumental experience. The instrument and the instrumental experience are the basis of the developpement of music. The mastery of sounds language is partially founded on an instrumental knowledge of sounds.
4. It's precisely that instrumental knowledge which is lacking when we have to discover the unheard part of sound universe produced by most of sound synthesis systems.
5. Thus, the first function of computer as musical creation tool is to give a representation of the instrumental universe such as we can experiment like in the true instrumental universe.
6. Representation implies necessarily a reduction of the real instrumental universe, but, at the same time, it introduces two new fundamental factors :
  - a broadening of that instrumental field towards unknown and otherwise impossible spaces,
  - a control of the represented field unreachable with real instruments.

# INSTRUMENTAL EXPERIMENT and the INSTRUMENT

gestual action  
multisensory perception  
"gestual perception"





## II. THE INSTRUMENTAL EXPERIMENT AND THE INSTRUMENT

1. What we mean by instrumental experiment is not only the "how to play traditional instrument".

It means more fundamentally the sum of all the sensory-motor experiments done, since our birth, over various environmental objects producing sound.

2. In this experiment the acoustical perception has a privileged role, but it is inseparable of :

- a motor action that we call gestual action,
- other perceptions. More precisely the perception in instrumental experiment is a multisensory and overall phenomenon. Three channels are concerned : gestual, acoustical and visual.

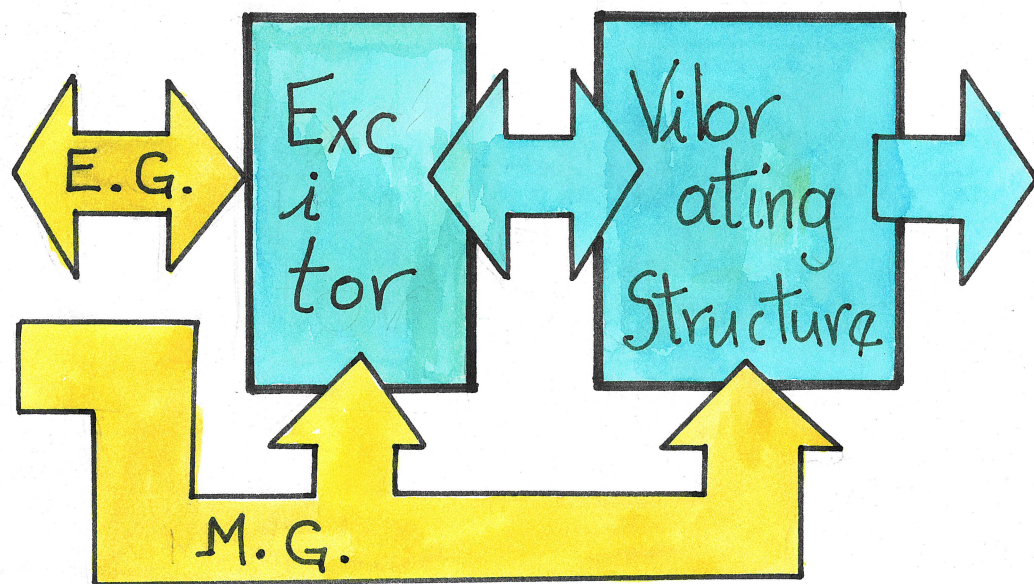
3. The gestual channel has a very special place because it is the only bilateral channel : It is simultaneously an emitter (of action) and a receiver (of perception).

We will call "gestual perception" the whole tactile or dynamical kinesthetic perception which accompany an action on a material object.

4. The visual channel has a complementary role over the two others : It takes place in a specific manner, in overall perception, as well as in the accomplishment of the instrumental gesture: giving information on the various objects and their relations it allows anticipation on instrumental playing.

# INSTRUMENT and INSTRUMENTAL GESTURE

Vibrating Structure  
Excitor



E.G. Excitation Gesture

M.G. Modification Gesture

### III. THE INSTRUMENT AND THE INSTRUMENTAL GESTURE

1. The instrument permits the gesture "to reach the ear". Its physical function consists in transforming a slow mechanical phenomenon in an acoustical phenomenon.
2. Generally, instruments are made of two mechanical macro components:
  - the vibrating structure whose mechanical movements are essentially acoustical,
  - the excitor whose mechanical movement are slow. It transforms the instrumental gesture in an excitation for the vibrating structure.
3. The specificity of the link between the excitor and the vibrating structure defines the way of transmission of the mechanical energy from the gesture to vibrating structure.
4. Generally, the instrumental gesture is of two natures: we shall call them the excitation gesture and the modification gesture.
5. The excitation gesture is the source of the sound energy. The role of the instrument is here to transform the mechanical energy produced by the gesture in an acoustical energy.

When a violonist plays, the left hand which holds the bow makes the excitation gesture.

This gesture is applied on the exciter which is then a mechanical load for the instrumentist. Two corollaries of this fact are :

  - the carrying out of the excitation gesture is influenced by the nature of the excitor,
  - the excitation gesture is inseparable from the gestual perception.

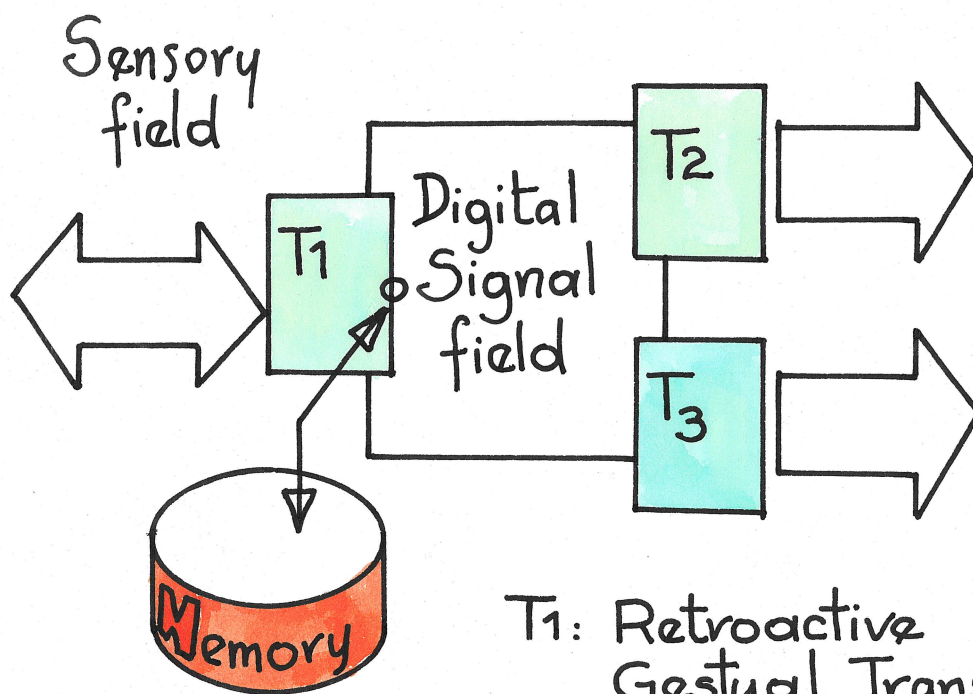
6. The modification gesture modifies the mechanical characteristics of the instrument and has as effect a modification of sound. When the violonist plays, the left hand makes the modification gesture : it modifies the string's length. In this case, the energy contribution is rather small and it doesn't take part in the energy of the sound. As a corollary, the gestual perception is not a necessary fact in the modification gesture.



# INSTRUMENTAL REPRESENTATION

## THREE MAIN FUNCTIONS

Transducers  
Simulating System  
Memorisation of Gesture



T1: Retroactive Gestural Transd.<sup>r</sup>

T2: Acoustical Transducer.

T3: Visual Transducer.

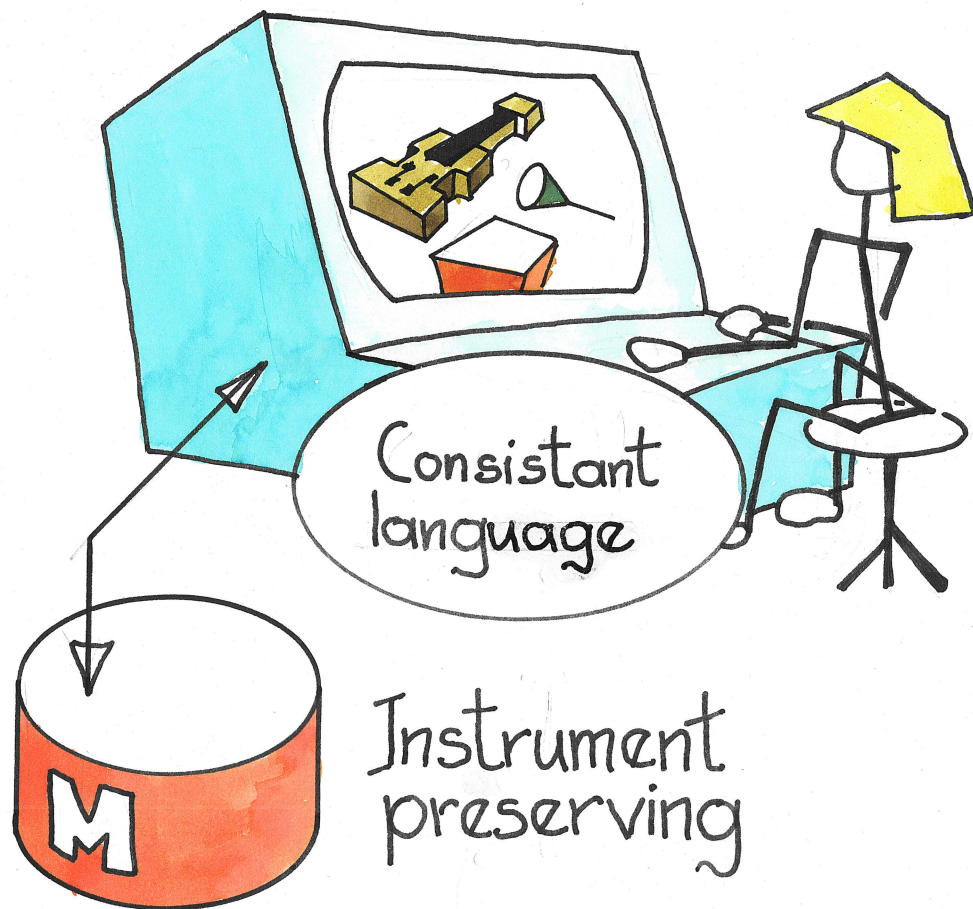
#### IV. THE FUNCTIONS OF THE MUSICAL CREATION TOOL (MCT) AND THE CORRESPONDING DEVICES

1. The central function of the "MCT" is the concrete representation of the instrumental field. It implies the creation of three kinds of devices :
  - a set of transducers
  - a system of simulation algorithms of instruments
  - a recording device for the instrumental gesture
2. The function of the transducers is to relate the events belonging to the sensory field and those belonging to the computer technology field, i.e. digital signals. There are three kinds of transducers, one for each of the three perception channels.
3. We must pay a particular attention to the specificity of gestual transducers, and especially gestual transducers with mechanical feedback (T.G.R.: in french: "Transducteurs Gestuels Rétroactifs") which support the bilaterality of gestual channel, especially for the excitation gesture.
4. The function of the system of algorithms is to calculate the digital signals which represent the movements of an object in a physically consistent way.
5. Conservation of instruments being made overthere, the recording of gestures assures an objective recording of the whole instrumental experiment.

**ABOVE**

Instrumental { Experiment  
(Playing)

Pre Structuring  
(instrument making)



## V. ABOVE THE INSTRUMENTAL EXPERIMENT

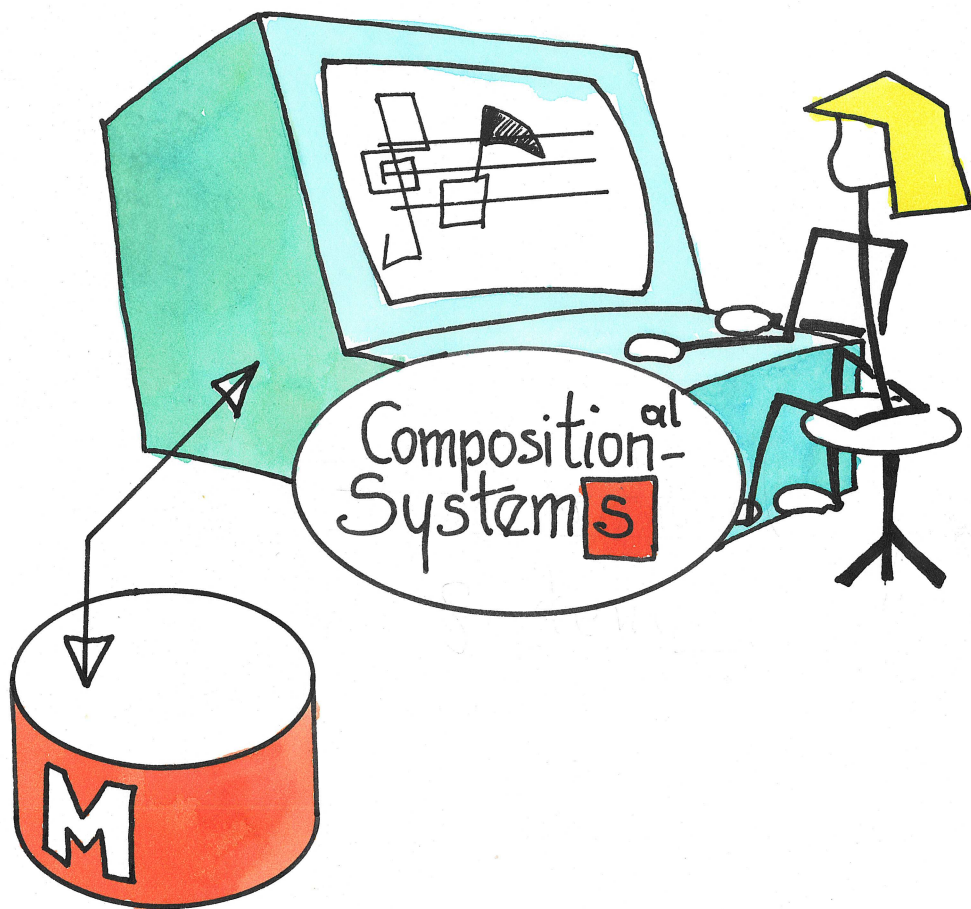
1. Above the effective simulation of instruments, a step of instrumental design, image of traditional instrument making, is necessary. This task will be supported by an appropriate system, "the pre-structural system".
2. This system depends on the set of algorithms for simulation but it must be also an explicite, consistant and complete language.
3. This step requires the design of an specific man-machine interface, especially supported by a non temporal graphic representation, explicit and interactive, of the instrumental structures.
4. The system must assure the recording of the instruments thus built.



**BELOW**

Instrumental { Experiment  
(Playing)

Acoustical Structuring  
(musical composition)



## VI.BELOW THE INSTRUMENTAL EXPERIMENT

1. The basic interest of instrumental universe computer representation is that any object (instrument) and any event (instrumental experiment) can be :
  - memorized in an objective and absolutely precise way
  - represented in a multidimensional and non- temporal form.
2. These two functions give way from the instrumental experiment to the compositional activity.
3. The third step is, then, the compositional step, which is a sound structuration, where their objects are the recorded gestures and instruments. It is essentially supported by a graphic representation of instrumental gesture.
4. We can developpe material composition systems that all will be treatment, transformation, combination and representation systems of instrumental gestures and structures.
5. The three steps -instrument making, instrumental playing, compositional structuring- here are in a logical, and not in a chronological, order.

## VII. MCT CONSTRUCTED AND EXPERIMENTED ELEMENTS

1. We briefly present now some of our system devices, already realized :

- a gestual transducer with mechanical feedback,
- the algorithm system and the CORDIS and ANIMA languages,
- the real-time special-purpose CORDIS processor.

2. The gestual transducer presented here is the second prototype constructed. Its external dimensions are similar to the dimensions of a piano key. It contains a force sensor with strain gauges, a displacement sensor with inductive effect (with 10  $\mu\text{m}$  of sensibility), and a torque motor. It is connected to the simulation system by means of conditioning devices and an appropriate interface.

3. The CORDIS simulation contains four basic elements corresponding to four kinds of digital algorithms. These four algorithms give the simulation of linear mechanical models which are: a ponctual mass, a stiffness element, a friction element, and a system of non-linear elements.

CORDIS is an entirely modular system whose elements may be combined, following only a consistant mechanical logic.

This system contains also primary modules corresponding to the most employed arrangements of the basic elements.

The CORDIS language allows the description of any mechanical structure (excitor or vibrating structure) by only these basic elements.

4. The ANIMA system describes the slow mechanical movments of the three different parts of the instrument. Based also on the previous mechanical elements, but versus the CORDIS system, the simulations are two-dimensional according to three levels : dynamic, geometric and graphic.

5. The real time CORDIS processor, connected to the host-computer gives the real time simulation of vibrating mechanical structures. It uses the three primary modules of the CORDIS system. It allows the real-time simulation, at a rate of 25,6 KHz sampling frequency, of vibrating structures composed by up to twelve material distinct points.

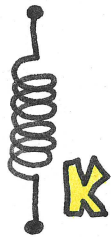
Its internal architecture is somehow similar of an array processor, using the technics of parallel and pipe-line architecture, and the specialisation of the memories. The computation is carried on a 32 bits fixed point format.



# the CORDIS System -



Ponctual  
mass



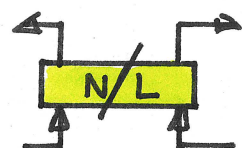
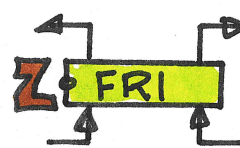
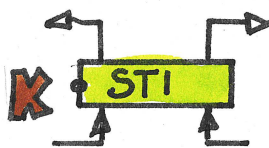
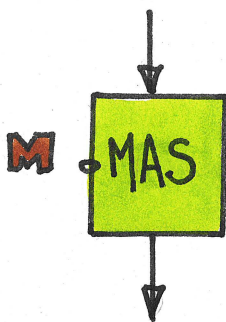
Stiffness  
element



Friction  
elem<sup>t</sup>.



Non linear  
elem<sup>t</sup>.



MAS 1

MAS 2

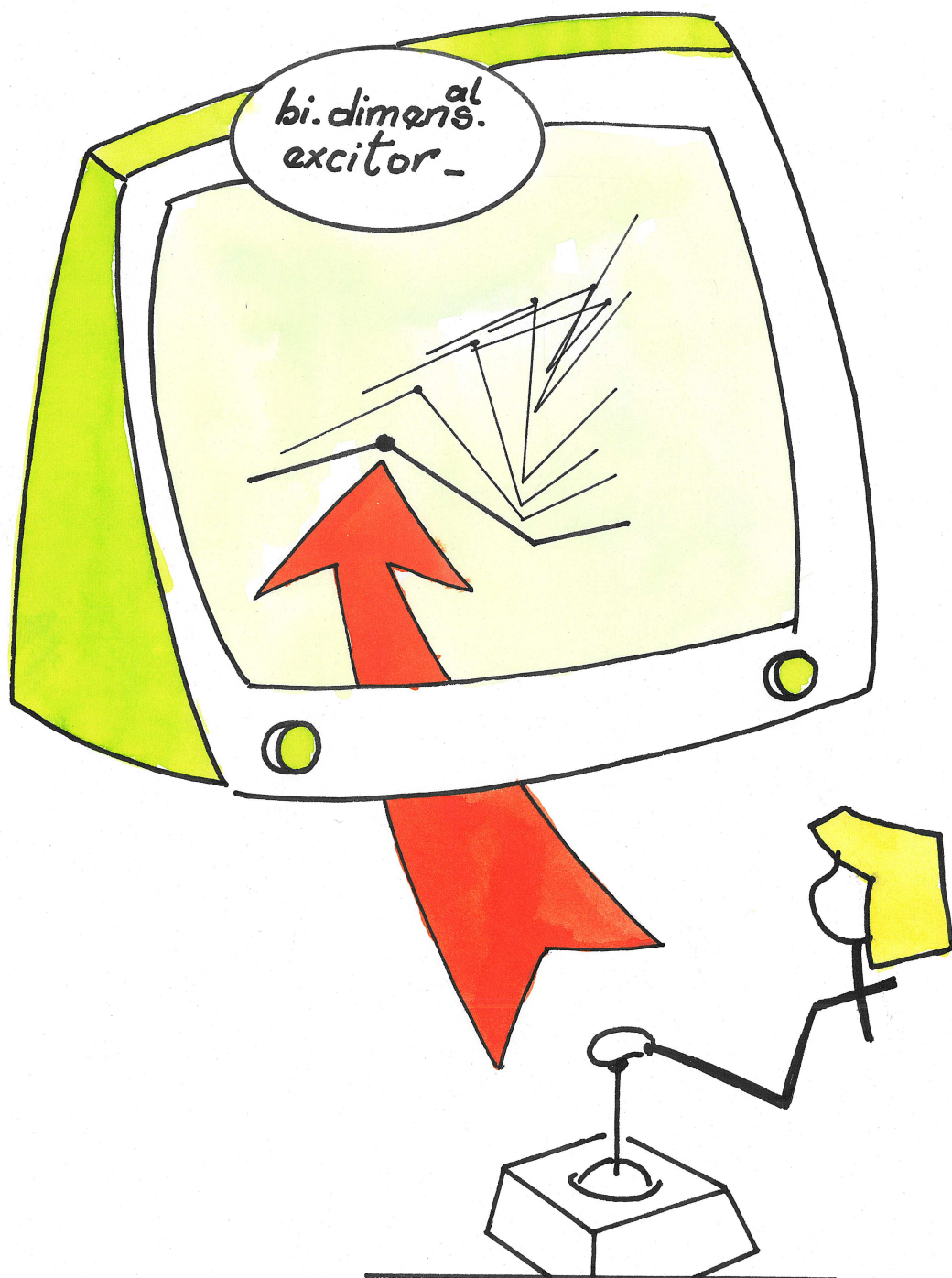
...

RES 1, MAS, 1, MAS, 2

FRO 1, MAS, 1, MAS, 2

etc...

# the ANIMA System -





Capteur de position.

Capteur de force.

Moteur.

